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Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number:

**0 069 409
B1**

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: 21.11.85

(51) Int. Cl.⁴: **C 07 D 307/32**

(21) Application number: **82200718.3**

(22) Date of filing: **11.06.82**

(54) **Process for the preparation of a 5-alkyl-butyrolactone.**

(30) Priority: **02.07.81 NL 8103173**

(43) Date of publication of application:
12.01.83 Bulletin 83/02

(45) Publication of the grant of the patent:
21.11.85 Bulletin 85/47

(84) Designated Contracting States:
BE CH DE FR GB IT LI NL

(58) References cited:
**GB-A- 684 111
US-A-2 368 366
US-A-2 786 852
US-A-3 278 557**

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Courier Press, Leamington Spa, England.

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Description

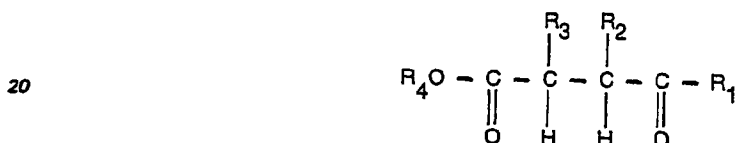
The invention relates to a process for the preparation of a 5-alkyl-butyrolactone.

From DE-B-1,013,642 it is known that levulinic acid can be hydrogenated in the gas phase to 5-methyl-butyrolactone (γ -valerolactone), with the aid of a copper-containing catalyst. According to said German patent specification, a very high yield can be obtained in this process.

However, when this known process for the preparation of 5-methyl-butyrolactone or another 5-alkyl-butyrolactone by hydrogenation of levulinic acid or another 4-oxo-alkane carboxylic acid was repeated, it appeared that the lifetime of the catalyst was very short indeed. After a reaction time of 20 hours, for instance, the conversion of the acid is considerably lower, and harmful side reactions occur to a considerable extent.

The invention now provides a process for the preparation of a 5-alkyl-butyrolactone without the abovementioned drawback.

The process according to the invention for the preparation of a 5-alkyl-butyrolactone is characterized in that a ketoester of formula



in which R_1 represents an alkyl group of 1—4 carbon atoms, R_2 and R_3 may each and independently represent hydrogen or an alkyl group of 1—4 carbon atoms and R_4 represents a hydrocarbon group with at most 8 carbon atoms, is reacted with hydrogen at a temperature of 150—325°C, in the gas phase and in the presence of a hydrogenation catalyst containing nickel and/or cobalt as metal and/or metal compound, and from the reaction mixture obtained a 5-alkyl-butyrolactone is recovered of the formula



where R_1 , R_2 and R_3 have the meaning indicated above.

As a by-product of the process according to the invention, an alcohol with the general formula R_4OH is formed R_4 having the meaning indicated above. The alcohol formed can be separated off from the reaction mixture by fractional distillation, and can be used, if desired, for the preparation, from the homologous keto-acid, of the keto-ester to be converted according to the invention.

By preference, alkyl groups with at most 4 carbon atoms are used as hydrocarbon group R_4 . Other hydrocarbon groups, with at most 8 carbon atoms, for example the groups cyclohexyl and benzyl, can also be used, but this does not result in any advantage.

The reaction according to the invention can be realized with known hydrogenation catalysts containing nickel and/or cobalt as metal and/or metal compound. The catalysts can be used on a support. Suitable supports are for instance active carbon, graphite, silicon oxide, chromium oxide, aluminium oxide, magnesium oxide, zinc oxide and mixtures of these materials.

The hydrogenation catalysts used in the process according to the invention are known as such and can for example be prepared (see G.H. van den Berg and H.Th. Ryn ten, Preparation of Catalysts II, Elsevier Amsterdam 1979, p. 265) by treating the support material with a salt of the relevant metal, followed by reduction with hydrogen. The amount of support material is chosen so that the amount of catalyst is, for example, 0.5—20 per cent by weight, preferably 1—10 per cent by weight (calculated as metal relative to the total amount of catalyst material, including the support).

The process according to the invention can be realized at various temperatures within the range 150—325°C. By preference, the temperature is chosen within the range 175—275°C, because then a high conversion and a good yield can be achieved.

For the practical realization of the reaction according to the invention, the modes of realization for gas-phase reactions known as such are suitable, for instance the mode of realization in which the starting product in a gaseous state and, if desired, diluted with an inert gas such as nitrogen, is passed over a fixed-bed catalyst together with hydrogen. The space velocity can be varied between, for instance, 0.01 and 2 grams of keto-ester per millilitre of catalyst material (compacted volume) per hour. The amount of hydrogen can also be varied, for example between 1 and 15 mol hydrogen per mol of keto-ester to be converted. It is also possible to use more than 15 mol hydrogen per mol of keto-ester to be converted, but this does not result in any advantage.

By cooling the gaseous reaction mixture, a condensate can be obtained, and a hydrogen-containing gas which can be recycled. From the condensate the desired product can be recovered by, for instance,

fractional distillation. It is also possible to recover the desired product from the condensate by extraction. The compounds obtained according to the invention can be used for various purposes, for example in the flavours and fragrances industry.

The invention will be further elucidated in the following examples

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Example I

For approximately 60 hours, a gaseous mixture of hydrogen and levulinic acid ethyl ester is passed downwards through a vertical tubular reactor (diameter 18 mm, length 400 mm) in which there is a zone of 25 ml (compacted volume) of catalyst. The catalyst zone is bounded on both sides by a zone of 25 ml inert ceramic material. The catalyst used is cobalt on a support of silica of moderate porosity (internal surface 350—500 m² per gram, activated by passing hydrogen over it for 16 hours at 350°C; 10% by weight Co) in the form of lumps with a diameter of 3—8 mm.

The gaseous mixture to be passed through (6 mol hydrogen per mol of ethyl ester) is obtained by evaporating liquid ethyl ester and mixing the vapour with hydrogen. Per ml (compacted volume) of catalyst, 0.2 gram ethyl ester is passed through per hour. For the first 47 hours, the temperature of the catalyst is maintained at 200°C with the aid of a heating jacket round the reactor, and afterwards at 250°C.

The composition of the reaction mixture is determined a number of times by leading the reaction mixture obtained through two series-arranged vessels which are cooled to 0°C and -80°C respectively, and analyzing the condensed product obtained in this way gas-chromatographically.

From this analysis, the weight of the amount of ester passed over during the period of two hours and the weight of the amount of condensed product caught during this period, the conversion of the ester and the lactone yield can be calculated.

By conversion is meant the amount of ester converted (the amount of ester passed over minus the amount of ester in the condensed product), expressed as a percentage of the amount of ester passed over.

By lactone yield is meant the amount of lactone in the condensed product, expressed as a percentage of the amount of lactone which it is theoretically possible to form from the amount of ester converted.

In the table below, the conversions and yields are presented, together with the operating time elapsed before the gaseous reaction mixture is going to be passed through the cooled vessels for the 2-hour period.

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Table

operating time in hours	conversion %	lactone yield %
21	99.7	99.5
45	98.8	99.5
48	97.9	99.5
55	92.6	99.5

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When instead of the ester the levulinic acid itself is passed over the catalyst under identical conditions, after as little as 20 hours the conversion has dropped to 30% and the yield to 50%.

Example II

In the way described in example I, a mixture of hydrogen and levulinic acid ethyl ester is passed over a copper-on-magnesium-oxide catalyst (38% by weight of Cu) in the form of tablets (diameter 5 mm, thickness 3 mm) for 5 hours. Per mol of ester 6 mol hydrogen are used. The temperature is maintained at 200°C, and the amount of ester passed over per ml of catalyst per hour is 0.2 gram.

After an operating time of 3 hours, the conversion and the lactone yield are determined in the way described in example I, and are found to be 99.8% and 99.5% respectively.

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Example III

In the way described in example I, a mixture of levulinic acid ethyl ester and hydrogen is passed over a copper chromite catalyst (80% by weight of CuO, 20% by weight of Cr₂O₃) in the form of tablets (diameter 3 mm, thickness 3 mm), for 94 hours. Per mol of ethyl ester, 6 mol hydrogen is used per hour, the temperature being maintained at 200°C. The amount of ester passed over per ml of catalyst per hour is 0.2 gram.

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The results found and the operating time are presented in the table below.

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Table

	operating time in hours	conversion in %	yield in %
5	3	99.4	99.0
	24	99.9	98.5
	48	99.8	99.6
10	68	99.5	98.4
	92	99.7	98.5

When, instead of the ester, the levulinic acid itself is passed over the catalyst in the same way, then after an operating time of 24 hours the conversion appears to have dropped to 23% and the yield to 22.5%.

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Example IV

In the manner described in example I, a mixture of hydrogen and 1,2-dimethyl-3-oxobutane-1-carboxylic acid methyl-ester is passed over a copper chromite catalyst (80% by weight of CuO and 20% by weight of Cr₂O₃) in the form of tablets (diameter 3 mm, thickness 3 mm, for 7 hours). Per mol of ester, 6 mol hydrogen is used. The temperature is maintained at 230°C, and per ml of catalyst 0.2 g ester is passed over per hour.

After 5 hours, the conversion of the ester and the yield of 3,4,5-trimethyl-butyrolactone is determined in the manner described.

These were 99% and 89%, respectively.

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Example V

In the manner described in example I, a mixture of hydrogen and levulinic acid ethyl ester is passed over a nickel-on-silicon oxide catalyst (10% by weight of Ni, Houdry type H 1170) in the form of lumps with a diameter of 3 to 5 mm, for 6 hours. Per mol of ester, 6 mol hydrogen is used, and the temperature is maintained at 220°C. Per ml of catalyst, 0.2 g ester is passed over per hour.

After an operating time of 4 hours, the conversion and the lactone yield are determined in the manner described. These are 99.5% and 99%, respectively.

Example VI

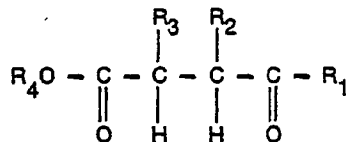
In the manner described in example I, a mixture of hydrogen and levulinic acid methyl ester is passed over a nickel-on-silicon-oxide catalyst (10% by weight of Ni, Houdry type H 1170) in the form of lumps with a diameter of 3 to 5 mm, for 7 hours. Per mol of ester, 6 mol hydrogen is used. Per ml of catalyst, 0.2 g ester is passed over per hour, and the temperature is maintained at 220°C.

After an operating time of 5 hours, the conversion and the lactone yield are determined in the manner described. These are 99% and 98.5%, respectively.

Claims

1. Process for the preparation of a 5-alkyl-butyrolactone, characterized in that a keto-ester of formula

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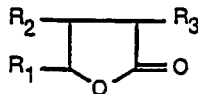


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in which R₁ represents an alkyl group of 1—4 carbon atoms, R₂ and R₃ may each and independently represent hydrogen or an alkyl group of 1—4 carbon atoms and R₄ represents a hydrocarbon group with at most 8 carbon atoms, is reacted with a hydrogen at a temperature of 150—325°C, in the gas phase and in the presence of a hydrogenation catalyst containing nickel and/or cobalt as metal and/or metal compound, and from the reaction mixture obtained a 5-alkyl-butyrolactone is recovered of the formula

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where R₁, R₂ and R₃ have the meaning indicated above.

2. Process according to claim 1, characterized in that the reaction with hydrogen is effected at a temperature of 175—275°C.

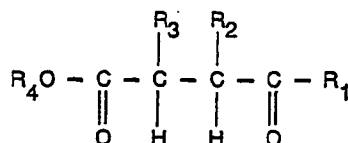
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3. Process according to claim 1 or 2, characterized in that the catalyst is used in the form of a fixed bed, and a space velocity of 0.01—2 gram keto-ester per ml catalyst material per hour is effected.

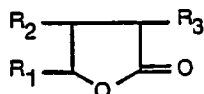
4. Process according to any one of the claims 1—3, characterized in that a keto-ester in which the R₄ group represents an alkyl group with at most 4 carbon atoms is used.

Patentansprüche

1. Verfahren zur Herstellung eines 5-Alkylbutyrolactons, dadurch gekennzeichnet, daß man einen Ketoester der Formel



worin R₁ eine Alkylgruppe mit 1—4 Kohlenstoffatomen darstellt, R₂ und R₃ jedes und unabhängig voneinander Wasserstoff oder ein Alkylgruppe mit 1—4 Kohlenstoffatomen darstellen und R₄ eine Kohlenwasserstoffgruppe mit höchstens 8 Kohlenstoffatomen darstellt, it Wasserstoff bei einer Temperatur von 150—325°C, in der Gasphase und in Gegenwart eines Nickel und/oder Kobalt als Metall und/oder Metallverbindung enthaltenden Hydrierungskatalysators umsetzt und aus dem erhaltenen Reaktionsgemisch ein 5-Alkylbutyrolacton der Formel



worin R₁, R₂ und R₃ die oben angegebene Bedeutung haben, gewinnt.

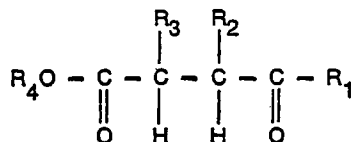
2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Reaktion mit Wasserstoff bei einer Temperatur von 175—275°C durchgeführt wird.

3. Verfahren nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß der Katalysator in Form eines Festbettes verwendet wird, und eine Raumgeschwindigkeit von 0,01—2 g Ketoester je ml Katalysator-material je Stunde bewirkt wird.

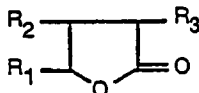
4. Verfahren nach einem der Ansprüche 1—3, dadurch gekennzeichnet, daß ein Ketoester, in welchem die Gruppe R₄ eine Alkylgruppe mit höchstens 4 Kohlenstoffatomen darstellt, verwendet wird.

Revendications

1. Procédé de préparation d'une 5-alcoyl-butylolactone, caractérisé en ce qu'on fait réagir un céto-ester de formule



où R₁ représente un groupe alcoyle en C1 à C4, R₂ et R₃ peuvent chacun représenter indépendamment un hydrogène ou un groupe alcoyle en C1 à C4 et R₄ représente un groupe hydrocarboné avec au plus 8 atomes de carbone, avec de l'hydrogène à une température de 150—325°C, en phase gazeuse et en présence d'un catalyseur d'hydrogénation contenant du nickel et/ou du cobalt comme métal et/ou composé métallique, et en ce qu'à partir du mélange réactionnel obtenu on recueille une 5-alcoyl-butylolactone de formule



où R₁, R₂ et R₃ ont la signification donnée ci-dessus.

2. Procédé selon les revendications 1 et 2, caractérisé en ce qu'on conduit la réaction avec l'hydrogène à une température de 175—275°C.

3. Procédé selon les revendications 1 et 2, caractérisé en ce que le catalyseur est utilisé sous la forme d'un lit fixe, et en ce qu'on produit une vitesse spatiale de 0,01—2 g de céto-ester par ml de matière catalyseur par heure.

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4. Procédé selon l'une quelconque des revendications 1—3, caractérisé en ce qu'on utilise un céto-ester où le groupe R4 représente un groupe alcoyle avec au plus 4 atomes de carbone.

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